CONTROLLED PITCH PROPELLER SYSTEM FOR SHIP USING LINEAR VARIABLE DIFFERENTIAL TRANSFORMER

Bashuraja S G¹, B S Shivashankar²
¹Department of Mechanical engineering M.Tech student (Industrial Automation and Robotics), MCE, Hassan
²Department of Mechanical engineering Associate professor (Industrial Automation and Robotics), MCE, Hassan

Abstract- Controlled Pitch Propellers (CPPs) are the system for ship, which are designed to maneuvering of the ship in forward and in reverse directions. This system usually designed with electronic control system as feedback. This paper is about non-contact sensor base electronic control system for the controlled pitch propeller. The feedback concepts in all available Controlled pitch propellers are contact base sensors or elements. The effort is made to increase the quality of the feedback element by the use of LVDT sensor with its unique features. With this effort the electronics control system will be fully automated to meet the present technology and creates a trend of non-contact sensor for the Controlled Pitch Propeller.

Keywords- Controlled Pitch Propeller, Maneuvering, Ahead, Astern, Ellipse SCADA, LVDT Sensor.

I. INTRODUCTION

The Controlled Pitch Propeller system consists of the propellers, the shaft line, the hydraulic system and the control system [1, 2, 5, 8]. The hydraulic system generates a hydraulic pressure to adjust the propeller blades (pitch) in any desired position. The pressurized oil flows through the inner and outer coaxial pipes into the cylinder yoke compartments in the hub, pushing the yoke backwards or forwards. A stationary oil distribution (OD) box, and feedback box, at the forward end of the gearbox output shaft takes care of the supply and distribution of the oil for the propeller pitch actuation. Oil flows through the OD box and shaft line into and out of the hub cylinder yoke compartments and hub cavity. The inner oil pipe inside the shaft (in the hub connected to the cylinder yoke) is connected to a feedback mechanism. An electronic control system transmits command of orders from the control station to the propulsion system. The control commands from the propeller pitch setting and the prime mover engine speed is given feedback to the controller. The propeller transforms the torque from the prime mover engine into the thrust force on the ship.

III. SYSTEM DESIGN AND METHODOLOGY

The block diagram consists of LVDT sensor, DC regulated power supply, Analog to digital converter etc. This block diagram was set for the simulation using SCADA software with derived drivers, PLC Tags, and Expression Tags. The linear movements were applied manually and readings noted through SCADA screens.

Figure 1. Feedback system
The letter LVDT stands for a Linear Variable Differential Transformer, a common type of electromechanical transducer. This converts the change in linear motion changes a core in a coil assembly, which is coupled mechanically into a corresponding electrical signal. LVDT internal structure is shown in figure 2. The LVDT Sensor is designed with primary and secondary coils, which induces current at both primary and secondary windings. In CPP there are only two positions (i.e., Ahead and Atern) can be at primary and secondary coils, output can be easily taken and processed according to the requirement. Linear Variable Differential Transformer sensors are readily available that can measure movements as small as a few millionths of an inch up to several inches, but are also capable of measuring position up to +20inches or -20 inches.

![Figure 2. LVDT construction](image)

Figures 3 illustrate the working principle of LVDT. It consists of one primary winding, two secondary windings and a core [3]. A core will be varying according to the magnetic flux is developed by the secondary windings. The primary winding P is energized by the constant source. The magnetic flux thus developed is coupled by the core to the adjacent secondary windings called S1 and S2. If the core is located midway between S1 and S2, then equal flux will be coupled to each secondary windings and their corresponding voltages are E1 and E2. Induced voltages in windings S1 and S2 respectively are equal. This position is called as Null Point differential voltage output (E1-E2), is essentially zero.

![Figure 3. LVDT in Null Position](image)

If the core is moved right closer to the winding S2 than to S1 as shown in figure 4, more flux will be coupled at S2 than at S1, that induced voltage E2 is increased while E1 is decreased, resulting in the differential voltage (E2-E1).
Conversely, if the core is moved left towards S1 as shown in figure 4, more flux will be coupled to S1 and less at S2, and hence the voltage E1 is increased as E2 is decreased, resulting in the differential voltage (E1-E2).

The figure 6 shows the graphical representation of core and is classified as A, B and C. A represents magnitude of differential output voltage at Eout, B represents phase angle changes made by the core and C represents phase shift of 180 degrees.

LVDTs are robust, absolute linear position displacement transducers inherently frictionless. They have a virtually infinite cycle life when properly used. LVDTs have been widely used in
applications such as power turbines, hydraulics, automation, aircraft, satellites, nuclear reactors, and many others. These transducers have low hysteresis and excellent repeatability.

**IV SIMULATION & ANALYSIS**

Simulation and Analysis is done by using ELIPSE SCADA Software. SCADA stands for Supervisory Control and Data Acquisition. Ellipse software is proud to present the powerful tool for creating and developing supervisory control applications. Ellipse SCADA gives a great performance and has powerful and innovative features to make the task of developing applications easier. It is completely configurable by the user and the process variables can be shown in a graphic form, allowing an easy understanding of what is going on in real time. The real time data can be interpreted to the user by using multiple screens such as Bars, Trends, Displays, Gauge, etc simultaneously on single screen. Besides this can send or receive information to data acquisition equipment using Set points, Sliders, and Buttons.

4.1. Ellipse SCADA Screen

Ellipse SCADA screen can configure too many other screens as shown in figure 7. Graphical representation and conversion screens. Here CPP screen displays or conveys pitch angles movement in degree (34.30 degree) and similar converted values to that pitch angle of degrees to corresponding current values in mA. This current value goes on changing according to changes occurred in the pitch angles.

![Figure 7. Pictorial view of SCADA Simulation](image)

Simulation is performed with LVDT. The hardware components used for simulation were MASIBUS (Process indicator with MODBUS RTU Interface), RS485 to USB Converter, LVDT Sensor, DC 24v Regulated Power Supply. Here main effort is to achieve the conversion of angle movements to their corresponding voltage values. Then the voltage is converted into current in terms of mA.

Since requirement was only for one PLC tag and one Expression tag. Hence PLC tag was configured with N addressing parameters according to selected MODBUS driver and scanned time set for updating values on the screens.
Table 1. LVDT Simulation Readings

<table>
<thead>
<tr>
<th>Pitch Angle</th>
<th>Current in mA</th>
</tr>
</thead>
<tbody>
<tr>
<td>-24.21</td>
<td>4.030</td>
</tr>
<tr>
<td>-20</td>
<td>4.158</td>
</tr>
<tr>
<td>-15</td>
<td>6.501</td>
</tr>
<tr>
<td>-10</td>
<td>7.844</td>
</tr>
<tr>
<td>-5</td>
<td>9.187</td>
</tr>
<tr>
<td>0</td>
<td>10.530</td>
</tr>
<tr>
<td>5</td>
<td>11.873</td>
</tr>
<tr>
<td>10</td>
<td>13.216</td>
</tr>
<tr>
<td>15</td>
<td>13.559</td>
</tr>
<tr>
<td>20</td>
<td>14.902</td>
</tr>
<tr>
<td>25</td>
<td>17.245</td>
</tr>
<tr>
<td>30</td>
<td>18.588</td>
</tr>
<tr>
<td>35.36</td>
<td>20.011</td>
</tr>
</tbody>
</table>

The N addressing parameters specify the nodal address of the RTU. The data values from register along with scan time are displayed on the screen. The MODBUS driver was also configured to read the required serial port (COM1) and the operational code was set as per the MODBUS RTU. Tags could read the input register values from the slave RTU with ID 01, function code 03 and data type integer (6, 4). Also the expression tag was generated from the PLC tag for displaying the current values in mA.

V. RESULT & DISCUSSION

The results obtained from the LVDT sensor signals in terms of milli Amperes (mA) and also pitch angles. Hence operational wise feedback system with a Linear Variable Differential Transformer has many advantages such as:[7] the LVDT sensor over the other types of sensor is the high degree of robustness, because there is no physical contact across the sensing element, there is no wear in the sensing element. The LVDT device relies on the coupling of magnetic flux leads to have an infinite resolution. Therefore the smallest fraction of the movement can be detected by suitable signal conditioning hardware, and the resolution is determined by the resolution of the data acquisition system. Some of other advantages are listed below:
1. High repeatability
2. High sensitivity
3. Very good linearity
4. Ruggedness
5. Low hysteresis
6. High shock and vibration immunity
7. Non-contacting core sensing technology.

V. CONCLUSION

Electronic Feedback control system plays a vital role in the Controlled Pitch Propeller since the manoeuvring of the overall system depends on the outcome of this system. The method explained in the paper helps to improve the life of the feedback system by providing reliable components. The use of LVDT sensor and other advanced automated components in the system provides high reliability, easy installation and less maintenance.
REFERENCES


